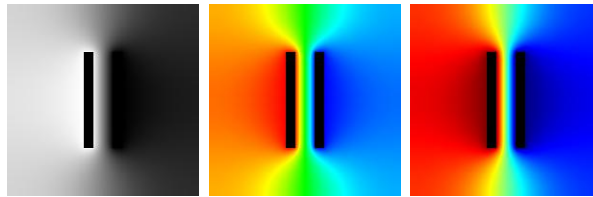


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# Liebmann technical documentation



2

3

Graphics.

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Mapping voltages to colours  
(colormaps).

5

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**version 8**

10

**2024.06.06**

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Lublin, Poland

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## 21 1 Liebmann technical documentation series

- |    |   |  |
|----|---|--|
| 22 | 1. Wyznaczanie rozkładu pola elektrostatycznego w próżni metodą relaksacyjną Liebmann. (Polish version)     |  |
| 23 |   |  |
| 24 | 2. Determination of electrostatic field distribution by using Liebmann relaxation method. (English version) |  |
| 25 |   |  |
| 26 | 3. Graphics. Mapping voltages to colours (colormaps).   |  |
| 27 | 4. Laplace equation 2D (XY). (Cartesian coordinates). Relaxation scheme explained (5 - point star)          |  |
| 28 |   |  |
| 29 | 5. Laplace equation 2D (ZR). (Cylindrical coordinates). Relaxation scheme explained (5 - point star).       |  |
| 30 |   |  |
| 31 | 6. Liebmann source code (ANSI C programming language).  |  |

## 32 2 Versions of this document

- |    |                           |  |
|----|---------------------------|--|
| 33 | 1. version 1 - 2023.11.03 |  |
| 34 | 2. version 2 - 2024.01.26 |  |
| 35 | 3. version 3 - 2024.02.02 |  |
| 36 | 4. version 4 - 2024.02.05 |  |
| 37 | 5. version 5 - 2024.02.27 |  |
| 38 | 6. version 6 - 2024.05.18 |  |

39 7. version 7 - 2024.05.26

40 8. version 8 - 2024.06.06

### 41 3 Mapping value $V$ to parameter $t$

42 Liebmann software uses PPM graphic file format, which has been described in  
43 Wikipedia [1] (package Netpbm).

44 We want to transform value of parameter  $V$  to colour value (3 pixel compo-  
45 nents: red/green/blue).

46 Parameter  $V$  can be potential of electric field, but it can be other value, such  
47 as electric force  $E$ .

48 Some Liebmann colour mapping recipes (Hot-To-Cold and Jet) work with  
49 paramter  $t$ , which has values in range  $[-1.0, \dots, +1.0]$ , whereas the value of  
50 parameter  $V$  lies in range  $[V_{min}, \dots, V_{max}]$  (they must be determined before  
51 mapping, beause we want to know the range of  $V$ ).

52 That's why the value of  $V$  must be „normalized“ - transformed from range  
53  $[-V_{min}, \dots, V_{max}]$  to range  $[-1.0, \dots, +1.0]$

54 The transformation is done by linerar function shown below.

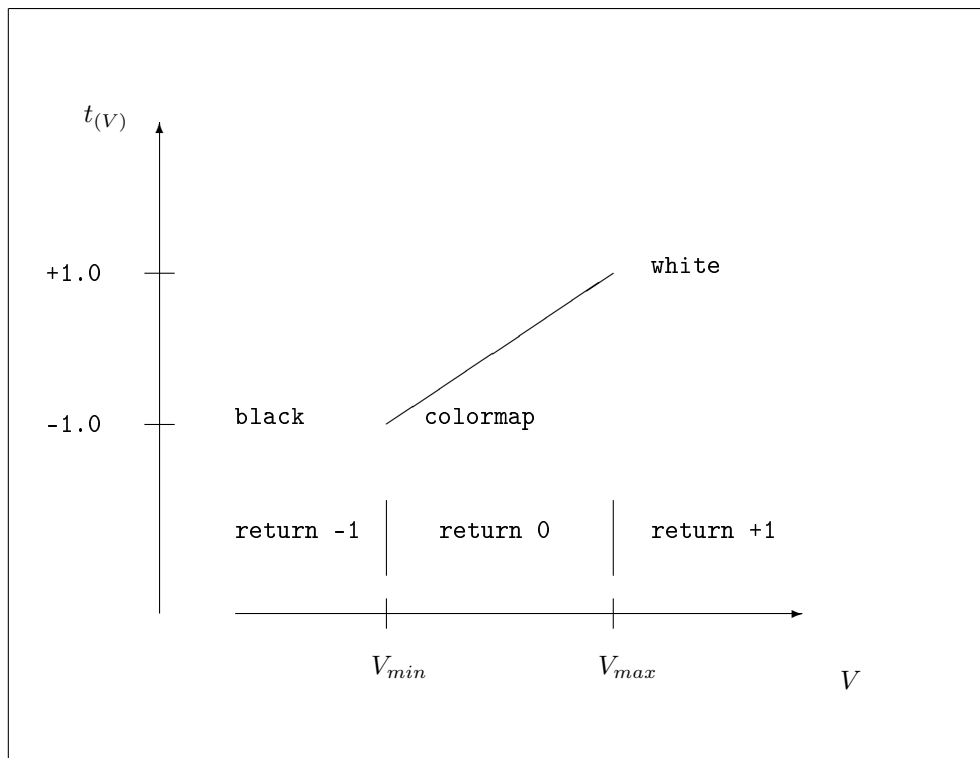


Figure 1: Mapping value  $V$  to parameter  $t$

55 It is also worth to say about return value. If value of parameter  $V$  lies in  
 56 range  $[V_{min}, ..., V_{max}]$ , then value 0 is returned (interpolation done properly). In  
 57 other cases return value is -1 ( $V < V_{min}$ ) or +1 ( $V > V_{max}$ ).

58 Summary:

- 59 1. if  $V < V_{min}$  then colour is black and return -1
- 60 2. if  $V_{min} \leq V \leq V_{max}$  then we use colormap to determine colour and  
 61 return 0
- 62 3. if  $V > V_{max}$  then colour is white and return +1

63 For „inverted” colour mapping (reversed), transformation is done by function  
 64 below.

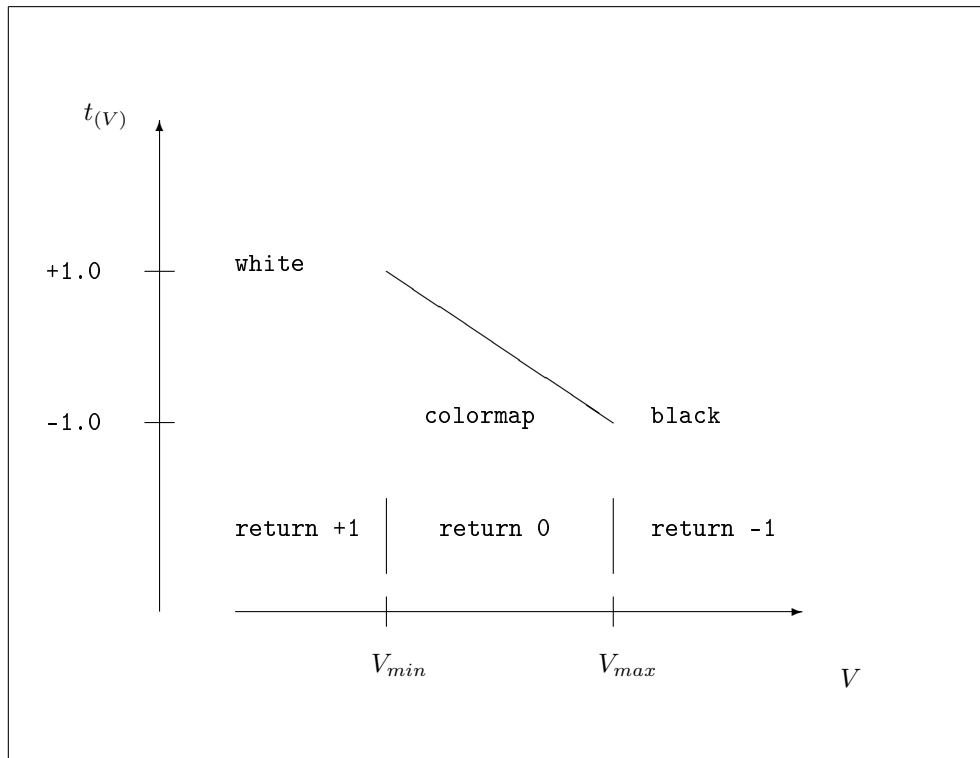


Figure 2: Inverted mapping value  $V$  to parameter  $t$

65 In this case the return value is also „inverted”.

66 Summary for inversed colour mapping:

- 67 1. if  $V < V_{min}$  then colour is white and return +1
- 68 2. if  $V_{min} \leq V \leq V_{max}$  then we use colormap to determine colour and  
 69 return 0
- 70 3. if  $V > V_{max}$  then colour is black and return -1

## 71 **4 clamp function**

72 Some Liebmann colour mapping uses also function `clamp` , which was found  
73 on Stackoverflow forum [2].

$$\text{clamp}_{[0,1]}(x) = \begin{cases} 0 & \text{if } x < 0 \\ x & \text{if } 0 \leq x \leq 1 \\ 1 & \text{if } x > 1 \end{cases} \quad (4.1)$$

## 74 5 Grayscale colormap

75 This colour mapping does not use parameter  $t$  and `clamp` function.

76 We have parameter  $V$  such that:  $V_{min} \leq V \leq V_{max}$ .

77 In our grayscale colormap any shade of grey has all the 3 parameters r/g/b  
78 the same.

$$r = g = b = \frac{V - V_{min}}{V_{max} - V_{min}} \quad (5.1)$$

79 All the r/g/b have values in range  $[+0.0, \dots, +1.0]$ . For PPM (P3) graphic  
80 file format these r/g/b values should be multiplied by maximal unsigned char  
81 value (255). Liebmann software uses Netpbm PPM P3 file format with unsigned  
82 char values (0, 1, 2, ..., 255).

83 For inverted grayscale colour mapping we use different formula:

$$r = g = b = \frac{V_{max} - V}{V_{max} - V_{min}} \quad (5.2)$$

84 And also all the r/g/b have values in range  $[+0.0, \dots, +1.0]$ . For PPM (P3)  
85 graphic file format these r/g/b values should be multiplied by maximal unsigned  
86 char value (255). Liebmann software uses Netpbm PPM P3 file format with  
87 unsigned char values (0, 1, 2, ..., 255).

## 88 6 Hot-to-cold colormap

89 This colour mapping was also found on Stackoverflow forum [2].

90 This colour mapping uses parameter  $t$  and `clamp` function.

91 If we determine value of parameter  $t$ , we can map its value to 3 values of  
92 pixel colour (red/green/blue).

$$\begin{aligned} r(t) &= \text{clamp}_{[0,1]}(2 - |2t - 2|) \\ g(t) &= \text{clamp}_{[0,1]}(2 - |2t|) \\ b(t) &= \text{clamp}_{[0,1]}(2 - |2t + 2|) \end{aligned} \quad (6.1)$$

$$-1.0 \leq t \leq +1.0 \quad (6.2)$$

93  $r/g/b$  have values in range  $[+0.0, \dots, +1.0]$ . For PPM (P3) graphic file format  
94 these  $r/g/b$  values should be multiplied by maximal unsigned char value (255).

95 Liebmann software uses Netpbm PPM P3 file format with unsigned char  
96 values (0, 1, 2, ..., 255).

## 97 7 Jet colormap

98 This colour mapping was also found on Stackoverflow forum [2].

99 This colour mapping uses parameter  $t$  and `clamp` function.

100 If we determine value of parameter  $t$ , we can map its value to 3 values of  
101 pixel colour (red/green/blue).

$$\begin{aligned} r(t) &= \text{clamp}_{[0,1]}(1.5 - |2t - 1|) \\ g(t) &= \text{clamp}_{[0,1]}(1.5 - |2t|) \\ b(t) &= \text{clamp}_{[0,1]}(1.5 - |2t + 1|) \end{aligned} \quad (7.1)$$

$$-1.0 \leq t \leq +1.0 \quad (7.2)$$

102  $r/g/b$  have values in range  $[+0.0, \dots, +1.0]$ . For PPM (P3) graphic file format  
103 these  $r/g/b$  values should be multiplied by maximal unsigned char value (255).

104 Liebmann software uses Netpbm PPM P3 file format with unsigned char  
105 values (0, 1, 2, ..., 255).

## 106 **References**

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111 [grayscale-to-red-green-blue-matlab-jet-color-scale](https://stackoverflow.com/questions/7706339/grayscale-to-red-green-blue-matlab-jet-color-scale), 2011.  
112 [Online; accessed 20-February-2023].